Show Changes Made," showing the current amendments to the claims is attached hereto.

Please amend the above-identified application as follows:

IN THE SPECIFICATION:

Please amend the specification as follows:

Delete the paragraph beginning at page 1, line 9, and ending at page 1, line 17, and replace with the following:

$\mathcal{B}^1$

In recent years, actuators have been proposed having two displacement elements such as a piezoelectric element or the like are arranged with their displacement directions set at a predetermined angle (e.g., 90°). In this actuator, an alternating current voltage signal having a specific phase difference drives each displacement element such that a drive member provided at the intersection point of the displacement elements moves in an elliptical path. This drive member abuts a driven member, and rotates or moves the driven member in a specific direction. Such an actuator is referred to as a truss-type actuator.

Delete the paragraph beginning at page 4, line 20, and ending at page 6, line 24, and replace with the following:

$\mathcal{B}^2$

These and other objects and features of the present invention will become apparent from the following description of the preferred embodiments thereof taken in conjunction with the accompanying drawings, in which:

FIG. 1 shows the structure of a laminate-type piezoelectric element;

FIG. 2 illustrates the relationship between the displacement (amount of distortion) of the piezoelectric element and the strength of the electric field generated between each electrode in the laminate-type piezoelectric element;

FIG. 3 shows the structure of a truss-type actuator using a laminate-

type piezoelectric element;

FIG. 4 shows the block structure of the drive circuit;

FIG. 5a shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 0 degrees;

FIG. 5b shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 45 degrees;

FIG. 5c shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 90 degrees;

FIG. 5d shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 135 degrees;

FIG. 5e shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 180 degrees;

FIG. 6a shows the path of the tip member when the actuator is under no load and a drive voltage of 30 V is applied;

FIG. 6b shows the path of the tip member when the actuator is under no load and a drive voltage of 40 V is applied;

FIG. 6c shows the path of the tip member when the actuator is under no load and a drive voltage of 50 V is applied;

FIG. 6d shows the path of the tip member when the actuator is under no load and a drive voltage of 60 V is applied;

FIG. 6e shows the path of the tip member when the actuator is under no load and a drive voltage of 70 V is applied;

FIG. 6f shows the relationship between the drive voltage and the diameter (displacement amount) of the path of the tip member;

FIG. 7 shows the relationship between the compression force applied by the spring of the actuator, and the contact interval between the tip member and the rotor;

B² cncl'd.

FIG. 8 shows the relationship between the speed (rotation) and load on the rotor in the actuator;

FIG. 9 shows the actuator output characteristics (load-to-drive efficiency characteristics);

FIG. 10 shows the elastic contact model generating elastic deformation in the contact area of the tip member and the rotor in the actuator;

FIG. 11 shows the relationship between the displacement of the piezoelectric element and the drive force generated thereby in the elastic contact model;

FIGS. 12a, 12b, 12c, 12d show the deportment when the piezoelectric element extends and contracts in the elastic contact model;

FIG. 13 shows the relationship between the displacement of the piezoelectric element and the compression force in each state in the elastic contact model;

FIG. 14 shows the structure of another embodiment of a truss-type actuator;

FIG. 15 shows the voltages applied to the two piezoelectric elements of the actuator, and the displacement resulting therefrom;

FIG. 16 shows a voltage applied to the first piezoelectric element and the second piezoelectric element; and

FIGS. 17a, 17b, 17c, 17d, 17d, 17e illustrate the principle of rotating the rotor by an actuator.

Delete the paragraph beginning at page 8, line 1, and ending at page 8, line 13, and replace with the following:

B³

When an alternating current drive voltage (AC signal) from the drive power source 16 is applied between the electrodes 12 and 13, the ceramic thin plates 11 repeatedly extend and contract in the same direction in accordance with the electric field, such that the entire piezoelectric element 10 repeatedly extends and contracts. The piezoelectric element 10 has an intrinsic resonance frequency determined by the electrical characteristics and structure of the piezoelectric element. When the frequency of the alternating current driver

B3
cncld.

voltage and the resonance frequency of the piezoelectric element 10 match, impedance is reduced, and the displacement of the piezoelectric element 10 is increased. The piezoelectric element 10 desirably uses this resonance phenomenon to drive at low voltage for small displacement relative to the external dimensions of the piezoelectric element 10.

Delete the paragraph beginning at page 11, line 6, and ending at page 11, line 19, and replace with the following:

B4

In FIG. 7, the vertical axis represents the contact ratio which is a ratio of the contact interval, during which the tip 20 is in contact with the rotor 40, to the entire time period, and the horizontal axis represents the compression force of the spring 41. When the voltage (drive signal amplitude) is 70 V, the contact interval between the tip 20 and the rotor 40 is near proportional to the compression force of the spring 41. When the voltage is 70 V, the amount of displacement of the piezoelectric elements 10 and 10' becomes large, and the speed of the tip 20 increases due to the elastic deformation speed (recovery speed) of the rotor 40 and tip 20 through the reaction force of the pressure applied by the spring 41, such that the tip 20 is completely separated from the rotor 40. As the compression force applied by the spring 41 increases, the recovery speed of the tip 20 and rotor 40 increases, and the time during which the tip 20 is separated from the rotor 40 becomes shorter.

Delete the paragraph beginning at page 13, line 28, and ending at page 14, line 16, and replace with the following:

B5

The relationship between the displacement of the piezoelectric elements 10 and 10' and the drive force generated by such displacement is shown in FIG. 11. In the drawing, the vertical axis represents the amount of displacement X of the piezoelectric elements 10 and 10', and the horizontal axis represents the force F generated by the piezoelectric elements. Since the piezoelectric elements 10 and 10' are displaced only an amount X0 when a voltage V0 is applied to the piezoelectric elements 10 and 10', a force

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$F0=k2 \cdot X0$ is generated at the ends of the piezoelectric elements 10 and 10'. Conversely, in the state wherein a voltage is not applied to the piezoelectric elements 10 and 10', the weight W at that end of the element is such that weight $W=F0$, and the piezoelectric elements 10 and 10' are displaced only $-X0$ (contracts only $X0$). Now assume a spring having a spring constant K is mounted in a state of free length to the piezoelectric elements 10 and 10'. When the amount of displacement when a voltage Vo is applied to the piezoelectric elements 10 and 10' is designated X, and the reaction force from the spring is designated F, the relationships $F0=(K+k2) \cdot X$, and $F=K \cdot X$ are obtained. When the value K is removed from these equations, the relationship $X=(F0-F)$ is obtained.

Delete the paragraph beginning at page 15, line 24, and ending at page 15, line 28, and replace with the following:

The relationship of each constant is determined using FIGS. 12a~12d. The compression force in FIGS. 12b, 12c, 12d are designated N, N', N''; the displacement of each element is designated ΔXn, $\Delta Xn'$, $\Delta Xn''$ (where n=1~3). Since the total length of the system is unchanged in these states, the following relationship is obtained.

Delete the paragraph beginning at page 16, line 9, and ending at page 16, line 10, and replace with the following:

Similarly, when N, N', N'' are substituted in the right side of equation (1), the following is obtained.

Delete the paragraph beginning at page 16, line 13, and ending at page 16, line 14, and replace with the following:

When N' is eliminated from equations (2) and (3), the following is obtained.

Delete the paragraph beginning at page 16, line 16, and ending at page 16, line 19, and replace with the following:

B9

When the critical compression force of the spring 41 at the time of transition from the intermittent contact state to the normal contact state between the tip 20 and the rotor 40 is designated Nt, since N"=0, the following is obtained.

Delete the paragraph beginning at page 16, line 21, and ending at page 16, line 24, and replace with the following:

B10

On the other hand, the amplitude Nw of the compression applied to the rotor 40 is normally constant in the normal contact state between the tip 20 and the rotor 40, such that from equation (3) the following is obtained.

Delete the paragraph beginning at page 18, line 5, and ending at page 18, line 9, and replace with the following:

B11

Since the spring constant k3 of the rotor 40 changes depending on the surface roughness and hardness of the contact surface of the tip 20, the contact surfaces may be made smooth by polishing the surfaces of the tip 20 and rotor 40, and increasing the hardness of the surface by a nitriding process or oxidation process.

Delete the paragraph beginning at page 18, line 21, and ending at page 19, line 2, and replace with the following:

B12

A first displacement element 60 and second displacement element 60' respectively comprise a single layer piezoelectric element (ceramic thin plate) 61 and 61', an elastic body 62, 62', and electrodes are not provided on both surfaces of the piezoelectric elements 61 and 61'. The first displacement element 60 and the second displacement element 60' are attached to the tip 20 and base 30 by bolts 63 and 63' without using adhesive. The elastic bodies 62 and 62' and the base 30 are respectively formed of electrically conductive material, drive power sources 16 and 16' are connected between the elastic

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B/2 cancel'd.

bodies 62, 62' and the base 30, so as to drive the first displacement element 60 and the second displacement element 60' at the previously described resonance frequency.

Delete the paragraph beginning at page 20, line 22, and ending at page 20, line 26, and replace with the following:

B/3

Accordingly, the actuator drive efficiency can be maximized and the actuator output can be simultaneously maximized by driving the displacement element such that the drive member and driven member are in a state of intermittent contact, and in a state near the condition of transition from the intermittent contact state to the normal contact state.